DESCRIPTION

REFRIGERANT FLOW SECTION CONNECTION STRUCTURE FOR USE IN REFRIGERATION CYCLE

CROSS REFERENCE TO RELATED APPLICATION

This application is an application filed under 35 U.S.C. §111(a) claiming the benefit pursuant to 35 U.S.C. §119(e)(1) of the filing date of Provisional Application No. 60/574,579 filed May 27, 2004 pursuant to 35 U.S.C. §111(b).

TECHNICAL FIELD

The present invention relates to a refrigerant flow section connection structure for use in a refrigeration cycle, and more particularly to a connection structure for connecting pipes of piping, connecting refrigerant flow sections, or connecting a pipe of piping and a refrigerant flow section in a supercritical refrigeration cycle that uses a supercritical refrigerant, such as CO_2 (carbon dioxide).

The term "refrigerant flow section" as used herein and in the appended claims includes pipes of piping in a refrigeration cycle in addition to sections of those apparatus which constitute the refrigeration cycle, such as a header of a heat exchanger, wherein a refrigerant flows through the sections.

BACKGROUND ART

A conventionally known gas cooler for use in a supercritical refrigeration cycle comprises a pair of header tanks arranged so as to be spaced apart from each other, heat exchange tubes arranged in parallel at intervals between the pair of header tanks and having opposite ends joined to the respective header tanks, and fins arranged in respective air passing clearances between adjacent pairs of heat exchange tubes, a connection block being attached to one of the header tanks, a pipe of a piping line extending from a compressor being connected to the connection block, another connection block being attached to the other header tank, and a pipe of a piping line extending from an expansion valve being connected to the connection block (publication of JP-A No. H11-351783, see FIG. 1).

In the gas cooler described in the publication, a flow path that communicates with a header tank via a pipe is formed at one end portion of each connection block, and a threaded hole is formed at the other end portion of each connection block. The above-mentioned publication does not describe the following pipe connection structure, but the structure is employed for connecting a pipe of piping to a gas-cooler-side connection block. A pipe-side connection block is prepared for connection with the gas-cooler-side connection block. The pipe-side connection block is identical in shape and size with the gas-cooler-side connection block and has a flow path formed in one end portion thereof and a bolt insertion hole formed in the other

end portion thereof. A male pipe portion to be inserted into an end portion of the flow path of the gas-cooler-side connection block is formed around one end opening of the flow path of the pipe-side connection block. An end portion of the pipe of piping is inserted into and welded to an end portion of the flow path of the pipe-side connection block opposite the male pipe portion. While the flow paths of the pipe-side connection block and the gas-cooler-side connection block are aligned with each other, the male pipe portion of the pipe-side connection block is inserted into the flow path of the gas-cooler-side connection block. In this condition, a bolt inserted through the bolt insertion hole of the pipe-side connection block is screwed into the threaded hole of the gas-cooler-side connection block, whereby the two connection blocks are fixedly joined together, and the pipe of piping is connected to the gas-cooler-side connection block.

However, the pipe connection structure of the gas cooler described in the above-mentioned publication involves the following problem.

A supercritical refrigeration cycle uses a working pressure about 10 times that employed by a refrigeration cycle that uses a chlorofluorocarbon refrigerant. According to the pipe connection structure in the gas cooler described in the above-mentioned publication, the flow path is formed in one end portion of each of the two connection blocks, and the other end portions of the two connection blocks are

joined by use of the bolt. This structure lacks in joining strength and withstand pressure. As a result, the structure entails the likelihood that the end portions of the two connection blocks associated with the flow paths are slightly detached from each other; in other words, the male pipe portion of the pipe-side connection block is slightly detached from the flow path of the gas-cooler-side connection block, resulting in leakage of refrigerant.

Such a problem may be solved by the following: the length of the two connection blocks are increased, the flow paths are formed in central portions of the connection blocks with respect to the direction of the length, and the connection blocks are joined together, by use of bolts, at respective opposite end portions with respect to the longitudinal direction. However, in this case, the number of parts increases, and workability of connection drops.

An object of the present invention is to overcome the above problems and to provide a refrigerant flow section connection structure having enhanced withstand pressure for use in a refrigeration cycle.

DISCLOSURE OF THE INVENTION

To fulfill the above object, the present invention comprises the following modes.

1) A refrigerant flow section connection structure for use in a refrigeration cycle comprising a channel member having a refrigerant channel communicating with a refrigerant

flow section via one end opening thereof, a pipe serving as a refrigerant flow section having a distal end portion fitted into the other end opening of the refrigerant channel of the channel member so as to be connected to the channel member, a fixing member for fixing the pipe to the channel member, and tightening means for joining the channel member and the fixing member together, either the channel member or the fixing member having an engaging portion to engage with a portion of the mating fixing member or the mating channel member so as to prevent detachment of the channel member and the fixing member from each other.

2) A refrigerant flow section connection structure for use in a refrigeration cycle according to par. 1), wherein the tightening means joins together an end portion of the channel member and an end portion of the fixing member; the refrigerant channel is formed in an end portion of the channel member opposite the end portion thereof subjected to joining by the tightening means; and the engaging portion of either the channel member or the fixing member is engaged with the portion of the mating fixing member or the mating channel member at the end portion of the channel member in which the refrigerant channel is formed.

3) A refrigerant flow section connection structure for use in a refrigeration cycle according to par. 1), wherein the tightening means joins together a longitudinally central portion of the channel member and a longitudinally central portion of the fixing member; the refrigerant channel is

formed in each of longitudinally opposite end portions of the channel member; and the engaging portion of either the channel member or the fixing member is engaged with the portion of the mating fixing member or the mating channel member at each of the opposite end portions of the channel member or the fixing member.

4) A refrigerant flow section connection structure for use in a refrigeration cycle according to par. 1), wherein the tightening means comprises a single threaded hole formed in the channel member, and a single bolt inserted through a bolt insertion hole formed in the fixing member and screwed into the threaded hole of the channel member.

5) A refrigerant flow section connection structure for use in a refrigeration cycle according to par. 1), wherein an annular projection is formed on the pipe in the vicinity of a distal end thereof along the entire circumference thereof; a portion of the pipe located distally of the annular projection is fitted into the other end opening of the refrigerant channel of the channel member; a cutout is formed in the fixing member in such a manner as to open at one side of the fixing member, and adapted to be fitted to a portion of the pipe located on a side opposite the portion thereof fitted into the refrigerant channel with respect to the annular projection; and the pipe whose distal end portion is fitted into the other end opening of the refrigerant channel of the channel member is fitted sideways into the cutout of the fixing member, whereby the engaging portion of either the

channel member or the fixing member is engaged with the portion of the mating fixing member or the mating channel member.

6) A refrigerant flow section connection structure for use in a refrigeration cycle according to par. 5), wherein a projecting portion is provided on the end portion of the channel member in which the refrigerant channel is formed, projects toward the fixing member, and extends along an end surface of the fixing member; a groove is formed on a surface of the projecting portion facing the end surface of the fixing member, and extends in a depth direction of the cutout of the fixing member; an outward projecting projection is provided on the end surface of the fixing member and adapted to be fitted into the groove; and a side wall of the groove located on a side toward a projecting end of the projecting portion serves as an engaging portion adapted to engage with the projection.

7) A refrigerant flow section connection structure for use in a refrigeration cycle according to par. 1), wherein a distal end portion of a channel-member-side pipe serving as a refrigerant flow section is fitted into the end opening of the refrigerant channel of the channel member, whereby the channel-member-side pipe is connected to the channel member.

8) A connecting process for a refrigerant flow section in a refrigeration cycle comprising:

preparing a channel member having a refrigerant channel formed in an end portion thereof and communicating with a

refrigerant flow section, and a threaded hole formed in the other end portion thereof; a fixing member having a cutout formed at one side thereof and located at an end portion thereof and a bolt insertion hole formed in the other end portion thereof; a pipe having an annular projection formed thereon in the vicinity of a distal end thereof along the entire circumference thereof, a portion of the pipe located distally of the annular projection being adapted to be fitted into the refrigerant channel of the channel member, a portion of the pipe located on the longitudinally inner side of the annular projection being adapted to be fitted into the cutout of the fixing member; and a bolt to be inserted through the bolt insertion hole of the fixing member and to be screwed into the threaded hole of the channel member;

providing a projecting portion on the end portion of the channel member in which the refrigerant channel is formed, in such a manner as to project toward the fixing member and to extend along an end surface of the fixing member; forming a groove on a surface of the projecting portion facing the end surface of the fixing member, the groove extending in a depth direction of the cutout of the fixing member; and providing an outward projecting projection on the end surface of the fixing member, the projection being adapted to be fitted into the groove;

fitting the portion of the pipe located distally of the annular projection into the refrigerant channel of the channel member;

fitting the fixing member sideways to the pipe, thereby fitting the portion of the pipe located on the longitudinally inner side of the annular projection into the cutout of the fixing member; fitting the projection of the fixing member into the groove of the channel member to thereby engage a side wall of the groove located on a side toward a projecting end of the projecting portion with the projection; and aligning the bolt insertion hole with the threaded hole of the channel member; and

inserting the bolt into the bolt insertion hole of the fixing member and screwing the bolt into the threaded hole of the channel member.

9) A connecting process for a refrigerant flow section in a refrigeration cycle comprising:

preparing a channel member having a refrigerant channel formed in each of opposite end portions thereof and communicating with a refrigerant flow section, and having a threaded hole formed therein between the refrigerant channels, a fixing member having a cutout formed at one side thereof and located at each of opposite end portions thereof, and having a bolt insertion hole formed therein between the cutouts, pipes each having an annular projection formed thereon in the vicinity of a distal end thereof along the entire circumference thereof, a portion of each of the pipes located distally of the annular projection being adapted to be fitted into the corresponding refrigerant channel of the channel member, a portion of each of the pipes located on the

longitudinally inner side of the annular projection being adapted to be fitted into the corresponding cutout of the fixing member, and a bolt to be inserted through the bolt insertion hole of the fixing member and to be screwed into the threaded hole of the channel member;

providing a projecting portion on each of opposite end portions of the channel member in such a manner as to project toward the fixing member and to extend along corresponding opposite end surfaces of the fixing member, forming a groove on a surface of each of the projecting portions facing the corresponding end surface of the fixing member, the grooves extending in a depth direction of the cutouts of the fixing member, and providing an outward projecting projection on each of the end surfaces of the fixing member, the projections being adapted to be fitted into the corresponding grooves;

fitting the portions of the pipes located distally of the annular projections into the corresponding refrigerant channels of the channel member;

fitting the fixing member sideways to the pipes, thereby fitting the portions of the pipes located on the longitudinally inner side of the annular projections into the corresponding cutouts of the fixing member, fitting the projections of the fixing member into the corresponding grooves of the channel member to thereby engage side walls of the respective grooves located on a side toward projecting ends of the projecting portions with the corresponding

projections, and aligning the bolt insertion hole with the threaded hole of the channel member; and

inserting the bolt into the bolt insertion hole of the fixing member and screwing the bolt into the threaded hole of the channel member.

10) A heat exchanger comprising a refrigerant inlet header, a refrigerant outlet header, and a refrigerant circulation path adapted to establish communication between the refrigerant inlet header and the refrigerant outlet header, wherein a pipe is connected to each of the refrigerant inlet and outlet headers by means of a refrigerant flow section connection structure according to par. 1), and the channel member is fixedly attached to each of the refrigerant inlet and outlet headers so as to establish communication between the refrigerant channel thereof and each of the inlet and outlet headers, which are refrigerant flow sections.

11) A refrigerant flow section connection structure for use in a refrigeration cycle comprising two channel members each having a refrigerant channel communicating with a refrigerant flow section, and tightening means for joining the two channel members together, one of the two channel members having an engaging portion to engage with a portion of the other channel member so as to prevent detachment of the two channel members from each other.

12) A refrigerant flow section connection structure for use in a refrigeration cycle according to par. 11), wherein

the tightening means joins together end portions of the two channel members; the mutually communicating refrigerant channels are formed in corresponding end portions of the two channel members opposite the end portions thereof subjected to joining by the tightening means; and the engaging portion of said one channel member is engaged with the portion of said other channel member at the end portions of the channel members in which the respective refrigerant channels are formed.

13) A refrigerant flow section connection structure for use in a refrigeration cycle according to par. 11), wherein the tightening means comprises a single threaded hole formed in , and a single bolt inserted through a bolt insertion hole formed in an end portion of said other channel member and screwed into the threaded hole of said one channel member.

14) A refrigerant flow section connection structure for use in a refrigeration cycle according to par. 11), wherein an insertion portion having an inner cylindrical surface is formed at an end portion of the refrigerant channel of said one channel member located on a side toward said other channel member; a male pipe portion having an outer cylindrical surface and adapted to be inserted into the insertion portion of the refrigerant channel of said one channel member is provided on a surface of said other channel member facing said one channel member and around an opening of the refrigerant channel of said other channel member; and while the male pipe portion of said other channel member is

inserted into the insertion portion of the refrigerant channel of said one channel member, said other channel member is rotated about a centerline of the male pipe portion in relation to said one channel member, whereby the engaging portion of said one channel member is engaged with the portion of said other channel member.

15) A refrigerant flow section connection structure for use in a refrigeration cycle according to par. 11), wherein a projecting portion is provided on the end portion of said one channel member in which the refrigerant channel is formed, projects toward said other channel member, and extends along an end surface of said other channel member; a groove is formed on a surface of the projecting portion facing the end surface of said other channel member, and extends in a width direction of the two channel members; an outward projecting projection is provided on the end surface of said other channel member and adapted to be fitted into the groove; and a side wall of the groove located on a side toward a projecting end of the projecting portion serves as an engaging portion adapted to engage with the projection.

16) A refrigerant flow section connection structure for use in a refrigeration cycle according to par. 11), wherein a distal end portion of a pipe of piping serving as a refrigerant flow section is fitted into an opening of the refrigerant channel of said one channel member located on a side opposite said other channel member, and a distal end portion of a pipe of piping serving as a refrigerant flow

section is fitted into an opening of the refrigerant channel of said other channel member located on a side opposite said one channel member, whereby the pipes of piping are connected to the corresponding channel members.

17) A connecting process for a refrigerant flow section in a refrigeration cycle comprising:

preparing a first channel member having a refrigerant channel formed in an end portion thereof and communicating with a refrigerant flow section, and a threaded hole formed in the other end portion thereof; a second channel member having a refrigerant channel formed in an end portion thereof and communicating with a refrigerant flow section, and a bolt insertion hole formed in the other end portion thereof; and a bolt to be inserted through the bolt insertion hole of the second channel member and to be screwed into the threaded hole of the first channel member;

providing a projecting portion on the end portion of the first channel member in which the refrigerant channel is formed, in such a manner as to project toward the second channel member and to extend along an end surface of the second channel member; forming a groove on a surface of the projecting portion facing the end surface of the second channel member, the groove extending in a width direction of the first and second channel members; and providing an outward projecting projection on the end surface of the second channel member, the projection being adapted to be fitted into the groove;

forming an insertion portion having an inner cylindrical surface at an end portion of the refrigerant channel of the first channel member located on a side toward the second channel member, and providing a male pipe portion having an outer cylindrical surface and adapted to be inserted into the insertion portion of the refrigerant channel of the first channel member, on a surface of the second channel member facing the first channel member and around an opening of the refrigerant channel of the second channel member;

inserting the male pipe portion of the second channel member into the insertion portion of the refrigerant channel of the first channel member in such a manner that the threaded hole of the first channel member and the bolt insertion hole of the second channel member are offset from each other;

rotating the second channel member about a centerline of the male pipe portion in relation to the first channel member, thereby aligning the threaded hole and the bolt insertion hole with each other and fitting the projection into the groove to thereby engage a side wall of the groove located on a side toward a projecting end of the projecting portion with the projection; and

inserting the bolt into the bolt insertion hole of the second channel member and screwing the bolt into the threaded hole of the first channel member.

18) A connecting process for a refrigerant flow section

in a refrigeration cycle comprising:

preparing a first channel member having a refrigerant channel formed in an end portion thereof and communicating with a refrigerant flow section, and a bolt insertion hole formed in the other end portion thereof; a second channel member having a refrigerant channel formed in an end portion thereof and communicating with a refrigerant flow section, and a threaded hole formed in the other end portion thereof; and a bolt to be inserted through the bolt insertion hole of the first channel member and to be screwed into the threaded hole of the second channel member;

providing a projecting portion on the end portion of the first channel member in which the refrigerant channel is formed, in such a manner as to project toward the second channel member and to extend along an end surface of the second channel member; forming a groove on a surface of the projecting portion facing the end surface of the second channel member, the groove extending in a width direction of the first and second channel members; and providing an outward projecting projection on the end surface of the second channel member, the projection being adapted to be fitted into the groove;

forming an insertion portion having an inner cylindrical surface at an end portion of the refrigerant channel of the second channel member located on a side toward the first channel member, and providing a male pipe portion having an outer cylindrical surface and adapted to be

inserted into the insertion portion of the refrigerant channel of the second channel member, on a surface of the first channel member facing the second channel member and around an opening of the refrigerant channel of the first channel member;

inserting the male pipe portion of the first channel member into the insertion portion of the refrigerant channel of the second channel member in such a manner that the threaded hole of the second channel member and the bolt insertion hole of the first channel member are offset from each other;

rotating the first channel member about a centerline of the male pipe portion in relation to the second channel member, thereby aligning the threaded hole and the bolt insertion hole with each other and fitting the projection into the groove to thereby engage a side wall of the groove located on a side toward a projecting end of the projecting portion with the projection; and

inserting the bolt into the bolt insertion hole of the first channel member and screwing the bolt into the threaded hole of the second channel member.

19) A heat exchanger comprising a refrigerant inlet header, a refrigerant outlet header, and a refrigerant circulation path adapted to establish communication between the refrigerant inlet header and the refrigerant outlet header, wherein a pipe serving as a refrigerant flow section is connected to each of the refrigerant inlet and outlet

headers by means of a refrigerant flow section connection structure according to par. 11), wherein said one channel member is fixedly attached to each of the refrigerant inlet and outlet headers so as to establish communication between the refrigerant channel thereof and the inlet or outlet header; and a distal end portion of the corresponding pipe is fitted into an end portion of the refrigerant channel of said other channel member located on a side opposite the male pipe portion, and joined to said other channel member.

20) A supercritical refrigeration cycle which comprises a compressor, a gas cooler, an evaporator, a pressure reducing device, and an intermediate heat exchanger for effecting heat exchange between a refrigerant flowing out of the gas cooler and a refrigerant flowing out of the evaporator and wherein a supercritical refrigerant is used, the gas cooler comprising a heat exchanger according to par. 10) or 19).

21) A vehicle having installed therein a supercritical refrigeration cycle according to par. 20) as a vehicle air conditioner.

22) A supercritical refrigeration cycle which comprises a compressor, a gas cooler, an evaporator, a pressure reducing device, and an intermediate heat exchanger for effecting heat exchange between a refrigerant flowing out of the gas cooler and a refrigerant flowing out of the evaporator and wherein a supercritical refrigerant is used, the evaporator comprising a heat exchanger according to par.

10) or 19).

23) A vehicle having installed therein a supercritical refrigeration cycle according to par. 22) as a vehicle air conditioner.

With the refrigerant flow section connection structure according to par. 1), either the channel member or the fixing member has an engaging portion to engage with a portion of the mating fixing member or the mating channel member so as to prevent detachment of the channel member and the fixing member from each other. This increases the joining strength between the channel member and the fixing member, thereby enhancing withstand pressure. Accordingly, even when the working pressure of a refrigeration cycle increases, the channel member and the fixing member do not detach from each other, thereby preventing detachment of a pipe and associated leakage of refrigerant. Further, an increase in the joining strength between the channel member and the fixing member enhances durability against vibration or the like.

With the refrigerant flow section connection structure according to par. 2), the tightening means joins together an end portion of the channel member and an end portion of the fixing member, and the refrigerant channel is formed in an end portion of the channel member opposite the end portion thereof subjected to joining by the tightening means. This entails poor joining strength between the channel member and the fixing member at the end portion of the channel member in which the refrigerant channel is formed, resulting in the

likelihood of detachment of the channel member and the fixing member from each other at the end portion. In spite of the likelihood, since the engaging portion of either the channel member or the fixing member is engaged with a portion of the mating fixing member or the mating channel member at the end portion of the channel member in which the refrigerant channel is formed, the joining strength between the channel member and the fixing member is increased. Accordingly, even when the working pressure of a refrigeration cycle increases, the channel member and the fixing member do not detach from each other at the end portion of the channel member in which the refrigerant channel is formed, thereby preventing detachment of a pipe and associated leakage of refrigerant.

With the refrigerant flow section connection structure according to par. 3), the tightening means joins together a longitudinally central portion of the channel member and a longitudinally central portion of the fixing member, and the refrigerant channel is formed in each of longitudinally opposite end portions of the channel member. This entails poor joining strength between the channel member and the fixing member at the opposite end portions of the channel member in which the respective refrigerant channels are formed, resulting in the likelihood of detachment of the channel member and the fixing member from each other on both sides. In spite of the likelihood, since the engaging portion of either the channel member or the fixing member is engaged with a portion of the mating fixing member or the

mating channel member at each of the opposite end portions of the channel member or the fixing member, the joining strength between the channel member and the fixing member is increased. Accordingly, even when the working pressure of a refrigeration cycle increases, the channel member and the fixing member do not detach from each other at the opposite end portions of the channel member in which the respective refrigerant channels are formed, thereby preventing detachment of a pipe and associated leakage of refrigerant.

The refrigerant flow section connection structure according to par. 4) enhances the workability of joining the channel member and the fixing member by the tightening means and reduces the number of parts. Increasing the number of tightening means; e.g., the number of the threaded holes and the bolts, is effective for increasing the joining strength between the channel member and the fixing member. However, this is accompanied by an increase in the number of parts and impairs workability of joining.

The refrigerant flow section connection structure according to pars. 5) and 6) enhances the workability of engaging the engaging portion of either the channel member or the fixing member with a portion of the mating fixing member or the mating channel member.

The connecting process for a refrigerant flow section according to pars. 8) and 9) enables connection of a pipe to the channel member in a relatively easy manner and enables the resultant refrigerant flow section connection structure

to provide increased joining strength between the channel member and the fixing member and thus enhanced withstand pressure. Accordingly, even when the working pressure of a refrigeration cycle increases, the channel member and the fixing member do not detach from each other, thereby preventing detachment of a pipe and associated leakage of refrigerant. Further, an increase in the joining strength between the channel member and the fixing member enhances durability against vibration or the like.

With the refrigerant flow section connection structure according to par. 11), one of the two channel members has an engaging portion to engage with a portion of the other channel member so as to prevent detachment of the two channel members from each other. Thus, the joining strength between the two channel members is increased, so that withstand pressure is enhanced. Accordingly, even when the working pressure of a refrigeration cycle increases, the two channel members do not detach from each other, thereby preventing leakage of refrigerant from between the two channel members. Further, an increase in the joining strength between the two channel members enhances durability against vibration or the like.

With the refrigerant flow section connection structure according to par. 12), the tightening means joins together end portions of the two channel members, and the mutually communicating refrigerant channels are formed in corresponding end portions of the two channel members

opposite the end portions thereof subjected to joining by the tightening means. This entails poor joining strength between the two channel members at the end portions of the two channel members in which the respective refrigerant channels are formed, resulting in the likelihood of detachment of the two channel members from each other at the end portions. In spite of the likelihood, since the engaging portion of one channel member is engaged with a portion of the other channel member at the end portions of the two channel members in which the respective refrigerant channels are formed, the joining strength between the two channel members is increased. Accordingly, even when the working pressure of a refrigeration cycle increases, the two channel members do not detach from each other at the end portions thereof in which the respective refrigerant channels are formed, thereby preventing leakage of refrigerant from between the two channel members.

The refrigerant flow section connection structure according to par. 13) enhances the workability of joining the two channel members by the tightening means and reduces the number of parts. Increasing the number of tightening means; e.g., the number of the threaded holes and the bolts, is effective for increasing the joining strength between the two channel members. However, this is accompanied by an increase in the number of parts and impairs workability of joining.

The refrigerant flow section connection structure according to pars. 14) and 15) enhances the workability of

engaging the engaging portion of one channel member with a portion of the other channel member.

The connecting process for a refrigerant flow section according to pars. 17) and 18) enables connection of refrigerant flow sections in a relatively easy manner and enables the resultant refrigerant flow section connection structure to provide increased joining strength between the two channel members and thus enhanced withstand pressure. Accordingly, even when the working pressure of a refrigeration cycle increases, the two channel members do not detach from each other, thereby preventing leakage of refrigerant from between the two channel members. Further, an increase in the joining strength between the two channel members enhances durability against vibration or the like.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view showing the overall construction of Embodiment 1 of a gas cooler to which the present invention is applied. FIG. 2 is a fragmentary view in vertical section showing the gas cooler of FIG. 1 as it is seen from rear frontward. FIG. 3 is a perspective view showing a first header tank of the gas cooler of FIG. 1. FIG. 4 is an exploded perspective view of the first header tank of the gas cooler of FIG. 1. FIG. 5 is an enlarged view in section taken along the line A-A in FIG. 2. FIG. 6 is an exploded perspective view of a second header tank of the gas cooler of FIG. 1. FIG. 7 is an enlarged view in section

taken along the line B-B in FIG. 2. FIG. 8 is an enlarged view in section taken along the line C-C in FIG. 2. FIG. 9 is an exploded perspective view of a connection structure for connecting an outflow pipe of piping to a refrigerant outlet of the gas cooler of FIG. 1. FIG. 10 is a view in section equivalent to FIG. 8, showing Embodiment 2 of a gas cooler to which the present invention is applied. FIG. 11 is an exploded perspective view equivalent to FIG. 9., showing the same. FIG. 12 is a perspective view showing the overall construction of Embodiment 3 of an evaporator to which the present invention is applied. FIG. 13 is a fragmentary view in vertical section showing the same as it is seen from rear frontward. FIG. 14 is an enlarged view in section taken along the line D-D in FIG. 13. FIG. 15 is an exploded perspective view showing a first header tank of the evaporator of FIG. 12. FIG. 16 is an exploded perspective view showing a second header tank of the evaporator of FIG. 12. FIG. 17 is an enlarged view in section taken along the line E-E in FIG. 13. FIG. 18 is an enlarged view in section taken along the line F-F in FIG. 13. FIG. 19 is an exploded perspective view showing a right end portion of the first header tank of the evaporator of FIG. 12. FIG. 20 is an exploded perspective view showing a connection structure for connecting an inflow pipe of piping and an outflow pipe of piping to a refrigerant inlet and a refrigerant outlet, respectively, of the evaporator of FIG. 12. FIG. 21 is a view in vertical section showing a connection structure for

connecting pipes of piping according to Embodiment 4 to which the present invention is applied.

BEST MODE OF CARRYING OUT THE INVENTION

Embodiments of the present invention will be described below with reference to the drawings.

In the following description, the term "aluminum" includes aluminum alloys in addition to pure aluminum.

In the description of Embodiments 1 to 3, the upper, lower, left-hand, and right-hand sides of FIGS. 1, 2, 12, and 13 will be referred to as "upper," "lower," "left," and "right," respectively. Further, the downstream side of flow of air through an air passing clearance between each adjacent pair of heat exchange tubes will be referred to as the "front," and the opposite side as the "rear."

Embodiment 1

This embodiment is shown in FIGS. 1 to 9 and is implemented by applying the present invention to a gas cooler for a supercritical refrigeration cycle.

With reference to FIGS. 1 and 2, the gas cooler 1 for use in supercritical refrigeration cycles wherein a supercritical refrigerant, such as CO_2, is used comprises two header tanks 2, 3 extending vertically and separated from each other in the left-right direction, a plurality of flat heat exchange tubes 4 arranged in parallel between the two header tanks 2, 3 and separated from one another in the vertical direction, corrugated fins 5 arranged in respective

air passing clearances between respective adjacent pairs of heat exchange tubes 4 and outside the heat exchange tubes 4 at the upper and lower ends of the cooler and each brazed to the adjacent pair of heat exchange tubes 4 or to the end tube 4, and side plates 6 of bare aluminum material arranged externally of and brazed to the respective fins 5 at the upper and lower ends. In the case of this embodiment, the header tank 2 at the right will be referred to as the "first header tank," and the header tank 3 at the left as the "second header tank."

With reference to FIGS. 3 and 4, the first header tank 2 comprises a header forming plate 7 made from a brazing sheet having a brazing material layer over opposite surfaces thereof, i.e., an aluminum brazing sheet according to the present embodiment, a tube connecting plate 8 made from a brazing sheet having a brazing material layer over opposite surfaces thereof, i.e., an aluminum brazing sheet according to the present embodiment, and an intermediate plate 9 interposed between the header forming plate 7 and the tube connecting plate 8 and made from a bare metal material, i.e., a bare aluminum material, the plates 7 to 9 being arranged in superposed layers and brazed to one another.

Formed in the header forming plate 7 and mutually separated in the vertically direction are a plurality of, i.e., two, outward bulging portions 11A, 11B extending vertically and equal in bulging height, length, and width. An opening of each of the outward bulging portions 11A, 11B

facing leftward is closed with the intermediate plate 9. The header forming plate 7 is made from an aluminum brazing sheet having a brazing material layer over opposite surfaces thereof by press work. A refrigerant inlet 12 is formed in the top of the upper bulging portion 11A of the plate 7, and a refrigerant outlet 13 is formed in the top of the lower bulging portion 11B.

The tube connecting plate 8 has a plurality of tube insertion holes 14 extending through the thickness thereof, elongated in the front-rear direction, and separated from one another in the vertical direction. The insertion holes 14 in the upper half of the plate 8 are provided within the vertical range of the upper bulging portion 11A of the header forming plate 7, and the insertion holes 14 in the lower half of the plate 8 are provided within the vertical range of the lower bulging portion 11B of the header forming plate. The front-to-rear length of each tube insertion holes 14 is slightly larger than the front-to-rear width of the outward bulging portion 11A or 11B, and the front and rear ends of the tube insertion hole 14 project outward beyond the respective front and rear edges of the bulging portion 11A or 11B (see FIG. 5). The tube connecting plate 8 is integrally provided at each of its front and rear side edges with a cover wall 15 projecting rightward to the outer surface of the header forming plate 7, covering the boundary between the plate 7 and the intermediate plate 9 over the entire length thereof and brazed to the front or rear side faces of the

plates 7, 9. The projecting end of the cover wall 15 is integrally provided with engaging portions 16 separated from one another in the vertical direction, engaging with the outer surface of the plate 7, and brazed to the plate 7. The tube connecting plate 8 is made from an aluminum brazing sheet having a brazing material layer over opposite surfaces thereof by press work.

The intermediate plate 9 has communication holes 17 extending through the thickness thereof and equal in number to the number of tube insertion holes 14 in the tube connecting plate 8 for causing the holes 14 to communicate with the outward bulging portion 11A or 11B of the plate 7 therethrough. The communication holes 17 are substantially larger than the insertion holes 14 (see FIG. 5). The communication holes 17 are positioned in corresponding relation with the respective tube insertion holes 14 of the tube connecting plate 8. The tube insertion holes 14 in the upper half of the plate 8 communicate with the interior of the upper bulging portion 11A through the communication holes 17 in the upper half of the intermediate plate 9, and the tube insertion holes 14 in the lower half of the plate 8 communicate with the interior of the lower bulging portion 11B through the communication holes 17 in the lower half of the intermediate plate 9. All the communication holes 17 communicating with the interior of the upper bulging portion 11A, as well as all the communication holes 17 communicating with the interior of the lower bulging portion 11B, are held

in communication by communication portions 18 formed by cutting away the portion between each adjacent pair of holes 17 in the intermediate plate 9. The intermediate plate 9 is made from a bare aluminum material by press work.

The second header tank 3 has approximately the same construction as the first header tank 2, and like parts are designated by like reference numerals (see FIG. 6). The two header tanks 2, 3 are arranged with their tube connecting plates 8 opposed to each other. The second header tank 3 differs from the first header tank 2 in that the header forming plate 7 has one outward bulging portion 19 which is one smaller in number than the number of outward bulging portions 11A, 11B of the first header tank 2 and which extends from the upper end of the header forming plate 7 to the lower end thereof so as to face both the bulging portions 11A, 11B of the first header tank 2, that the outer bulging portion 19 has neither of the refrigerant inlet and outlet, that all tube insertion holes 14 of the tube connecting plate 8 communicate with the interior of the bulging portion 19 through all the communication holes 17 in the intermediate plate 9, and that all the communication holes 17 of the intermediate plate 9 are held in communication by communication portions 18 formed by cutting away the portion between each adjacent pair of communication holes 17.

The header tanks 2, 3 are made in the following manner. First are formed header forming plates 7 having outward bulging portions 11A, 11B or an outward bulging portion 19,

tube connecting plates 8 having tube insertion holes 14, cover walls 15, and engaging portion forming lugs 16A (represented by solid lines in FIGS. 4 and 6) extending straight from each of the cover walls 19, and intermediate plates 9 having communication holes 17 and communication portions 18. Subsequently, the three plates 7, 8, 9 for each of the header tanks 2, 3 are fitted together in superposed layers, and then the lugs 16A are bent to form engaging portions 16. Utilizing the brazing material layers of the plates 7, 8, the three plates 7, 8, 9 of each assembly are then brazed to one another, the cover walls 15 are brazed to the front and rear side faces of the intermediate plate 9 and header forming plate 7, and the engaging portions 16 are brazed to the plate 7.

Each of the heat exchange tubes 4 is made from a metal extrudate, i.e., an aluminum extrudate in the present embodiment, is in the form of a flat tube having an increased width in the front-rear direction, and has inside thereof a plurality of refrigerant channels 4a extending longitudinally thereof and arranged in parallel. The heat exchange tubes 4 are brazed to the tube connecting plates 8 of the two header tanks 2, 3 using the brazing material layers of the plates 8, with their opposite ends placed into the respective tube insertion holes 14 of the tanks 2, 3. Each end of the tube 4 is placed into the communication hole 17 of the intermediate plate 9 to an intermediate portion of the thickness thereof (see FIG. 2). The heat exchange tubes 4 in the upper half of

the cooler to be fabricated have their right ends connected to the first header tank 2 so as to communicate with the interior of the upper outward bulging portion 11A, and have their left ends connected to the second header tank 3 so as to communicate with the interior of the outward bulging portion 19. Further, the heat exchange tubes 4 in the lower half have their right ends connected to the first header tank 2 so as to communicate with the interior of the lower outward bulging portion 11B, and have their left ends connected to the second header tank 3 so as to communicate with the interior of the outward bulging portion 19.

Each of the corrugated fins 5 is made in a wavy form from a brazing sheet having a brazing material layer over opposite surfaces thereof, i.e., an aluminum brazing sheet according to the present embodiment.

In the gas cooler 1 described above, an upper half portion of the first header tank 2 including the upper outward bulging portion 11A serves as a refrigerant inlet header 21 serving as a refrigerant flow section, and a lower half portion including the lower outward bulging portion 11B serves as a refrigerant outlet header 22 serving as a refrigerant flow section. All the heat exchange tubes 4 and the second header tank 3 form a refrigerant circulation path establishing communication between the refrigerant inlet header 21 and the refrigerant outlet header 22.

An inflow pipe 25 of piping and an outflow pipe 25 of piping are connected to the refrigerant inlet header 21 and

the refrigerant outlet header 22, respectively, by means of respective refrigerant flow section connection structures 23. The two refrigerant flow section connection structures 23 have the same configuration, and only the refrigerant flow section connection structure 23 used for connection of the outflow pipe 25 of piping will be illustrated in detail.

With reference to FIGS. 7 to 9, the refrigerant flow section connection structure 23 comprises a channel member 26 joined to the outer surface of the lower outward bulging portion 11B of the first header tank 2, i.e., the refrigerant outlet header 22, the pipe 25 of piping, a fixing member 27 adapted to fix the pipe 25 of piping to the channel member 26, and a tightening means for joining the channel member 26 and the fixing member 27 together.

The channel member 26 is made from metal, i.e., a bare aluminum material in the present embodiment, assumes the form of a block having a vertically elongated rectangular shape as viewed from the rear side, and has a refrigerant channel 28 whose one end opening communicates with the interior of the refrigerant inlet header 21 or the refrigerant outlet header 22 via the refrigerant inlet 12 or the refrigerant outlet 13 and whose other end opens at an upper end portion of the rear surface of the channel member 26. An insertion portion 28a having an inner cylindrical surface is formed at a rear end portion of the refrigerant channel 28. The channel member 26 has a projecting portion 29 integrally formed on the upper end surface thereof, projecting rearward beyond the rear

surface thereof, and extending along the upper end surface of the fixing member 27, as well as a groove 31 formed on the lower surface of the projecting portion 29 and extending in the left-right direction. The left and right ends of the groove 31 open at the left and right side faces, respectively, of the projecting portion 29. A side wall partially constituting the groove 31 and located on a side toward the projecting end of the projecting portion 29 serves as an engaging portion 32 that engages with a projection 35 of the fixing member 27 to be described later. Utilizing a brazing material of the outer surface of the header forming plate 7, the channel members 26 are brazed to the refrigerant inlet header 21 and the refrigerant outlet header 22, respectively.

The pipe 25 of piping has an annular bead 25a (annular projection) formed thereon in the vicinity of a distal end thereof along the entire circumference thereof. An O-ring 33 is fitted to the outer surface of a portion of the pipe 25 of piping located distally of the annular bead 25a.

The fixing member 27 is made from metal, i.e., a bare aluminum material in the present embodiment, and assumes the form of a block having a vertically elongated circular shape as viewed from the rear side. A cutout 34 is formed at an upper end portion of the fixing member 27 in such a manner as to open leftward (at left side face), and adapted to be fitted to a portion of the pipe 25 of piping located rearward (located on the longitudinally inner side) of the annular bead 25a. A recess 27a into which the annular bead 25a of

the pipe 25 of piping is fitted is formed on the front surface of the fixing member 27 around the front end opening of the cutout 34. The projection 35 is integrally formed on the upper end surface of the fixing member 27, projects upward, and is adapted to be fitted into the groove 31 of the channel member 26. The projecting height of the projection 35 is equal to the depth of the groove 31, and the front-rear length of the projection 35 is equal to the front-rear width of the groove 31. The upper surface of the projection 35 assumes the form of an upward projecting arc as viewed from the rear side.

The tightening means comprises a threaded hole 36 formed in the channel member 26 and extending frontward from a lower end portion of the rear surface of the channel member 26, and a bolt 38 to be inserted from the front side through a bolt insertion hole 37 formed in a lower end portion of the fixing member 27 and extending therethrough in the front-rear direction, and to be screwed into the threaded hole 36 of the channel member 26.

The pipe 25 of piping is connected to each of the refrigerant inlet header 21 and the refrigerant outlet header 22 in the following manner.

First, a portion of the pipe 25 of piping located distally of the annular bead 25a is inserted into the insertion portion 28a of the refrigerant channel 28 of the channel member 26. Next, the fixing member 27 is moved leftward from the right side so as to fit the projection 35

into the groove 31 of the channel member 26, to fit a portion of the pipe 25 of piping located on the longitudinally inner side of the annular bead 25a into the cutout 34, and to align the bolt insertion hole 37 and the threaded hole 36 with each other. At this time, the annular bead 25a of the pipe 25 of piping is fitted into the recess 27a of the fixing member 27. Then, the bolt 38 is inserted from the front side through the bolt insertion hole 37 of the fixing member 27 and screwed into the threaded hole 36 of the channel member 26. Thus, the pipe 25 of piping is connected to the refrigerant outlet header 22.

The gas cooler 1 provides a supercritical refrigeration cycle along with a compressor, an evaporator, an expansion valve serving as a pressure reducing device, an accumulator serving as a gas-liquid separator, and an intermediate heat exchanger for effecting heat exchange between a refrigerant flowing out of the gas cooler and a refrigerant flowing out of the evaporator and passing through the gas-liquid separator, and the refrigeration cycle is installed in vehicles, for example, in motor vehicles, as a vehicle air conditioner.

With the gas cooler 1 described above, CO_2 passing through a compressor flows through the inflow pipe 25 of piping and the refrigerant channel 28 of the channel member 26, then flows through the inlet 12 into the interior of the refrigerant inlet header 21, and thereafter dividedly flows into the refrigerant channels 4a of all the heat exchange

tubes 4 in communication with the interior of the upper bulging portion 11A. The CO_2 in the channels 4a flows leftward through the channels 4a and enters the bulging portion 19 of the second header tank 3. The CO_2 in the portion 19 flows down through the portion 19, the communication holes 17, and the communication portions 18, then dividedly flows into the channels 4a of all the heat exchange tubes 4 in communication with the lower bulging portion 11B, changes its course, flows rightward through the channels 4a, and enters the refrigerant outlet header 22. The CO_2 thereafter flows out of the cooler from the outflow pipe 25 of piping via the refrigerant outlet 13 and the refrigerant channel 28 of the channel member 26. While flowing through the channels 4a of the heat exchange tubes 4, the CO_2 is subjected to heat exchange with the air flowing through the air passing clearances in the direction of arrow X shown in FIG. 1, and is thereby cooled.

In Embodiment 1, the channel member 26 has the engaging portion 32, whereas the fixing member 27 has the projection 35 which engages with the engaging portion 32. This may be reversed such that the channel member 26 has the projection 35, whereas the fixing member 27 has the engaging portion 32 which engages with the projection 35.

Embodiment 2

This embodiment is shown in FIGS. 10 to 11 and is implemented by applying the present invention to a gas cooler for a supercritical refrigeration cycle.

The gas cooler of Embodiment 2 differs from that of Embodiment 1 in a refrigerant flow section connection structure for connecting an inflow pipe of piping to the refrigerant inlet header 21 and a refrigerant flow section connection structure for connecting an outflow pipe of piping to the refrigerant outlet header 22 and is similar in other configurational features to that of Embodiment 1.

Two refrigerant flow section connection structures 40 of Embodiment 2 have the same configuration, and only the refrigerant flow section connection structure 40 used for connection of the outflow pipe of piping will be illustrated.

The refrigerant flow section connection structure 40 comprises a first channel member 41 joined to the outer surface of the outward bulging portion 11A or 11B, i.e., the refrigerant inlet header 21 or the refrigerant outlet header 22, a second channel member 42 to be fixed to the first channel member 41, and a tightening means for joining the channel members 41 and 42 together.

The first channel member 41 has the same configuration as that of the channel member 26 of the gas cooler of Embodiment 1, and like parts are designated by like reference numerals.

The second channel member 42 is made from metal, i.e., a bare aluminum material in the present embodiment, and assumes the form of a block having a vertically elongated circular shape as viewed from the rear side. The second channel member 42 has a refrigerant channel 43 formed therein

and extending therethrough in the front-rear direction. The refrigerant channel 43 has a large-diameter portion 43a formed at a rear end portion thereof. A distal end portion of a pipe 44 of piping serving as a refrigerant flow section is inserted into the large-diameter portion 43a of the refrigerant channel 43 and joined to the second channel member 42 by welding or brazing. A male pipe portion 42a projecting frontward and having an outer cylindrical surface is integrally formed on the front surface of the second channel member 42 around the front end opening of the refrigerant channel 43. An O-ring 45 is fitted to the outer surface of the male pipe portion 42a. A projection 46 is integrally formed on the upper end surface of the second channel member 42, projects upward, and is adapted to be fitted into the groove 31 of the first channel member 41. The projecting height of the projection 46 is equal to the depth of the groove 31, and the front-rear length of the projection 46 is equal to the front-rear width of the groove 31. The upper surface of the projection 46 assumes the form of an upward projecting arc as viewed from the rear side. The distance between the centerline of the outer surface of the male pipe portion 42a and the upper end of the projection 46 is equal to the distance between the centerline of the insertion portion 28a of the refrigerant channel 28 of the first channel member 41 and the bottom surface of the groove 31.

The tightening means has the same configuration as that

of the tightening means of the gas cooler of Embodiment 1, and like parts are designated by like reference numerals.

The pipe 44 of piping is connected to each of the refrigerant inlet header 21 and the refrigerant outlet header 22 in the following manner.

First, the male pipe portion 42a of the second channel member 42 is inserted into the insertion portion 28a of the refrigerant channel 28 of the first channel member 41. At this time, the bolt insertion hole 37 of the second channel member 42 is offset, i.e., offset counterclockwise in the present embodiment as viewed from the rear side, from the threaded hole 36 of the first channel member 41. Then, the second channel member 42 is rotated about the centerline of the outer surface of the male pipe portion 42a, thereby fitting the projection 46 of the second channel member 42 into the groove 31 of the first channel member 41 and aligning the bolt insertion hole 37 and the threaded hole 36 with each other. The bolt 38 is inserted from the front side through the bolt insertion hole 37 of the fixing member 27 and screwed into the threaded hole 36 of the first channel member 41. Thus, the pipe 44 of piping is connected to the refrigerant outlet header 22.

In Embodiment 2, the first channel member 41 has the engaging portion 32, whereas the second channel member 42 has the projection 46 which engages with the engaging portion 32. This may be reversed such that the first channel member 41 has the projection, whereas the second channel member 42 has

the engaging portion which engages with the projection 46.

Embodiment 3

This embodiment is shown in FIGS. 12 to 20 and is implemented by applying the present invention to an evaporator for a supercritical refrigeration cycle.

With reference to FIGS. 12 to 14, the evaporator 50 for use in supercritical refrigeration cycles wherein a supercritical refrigerant, such as CO_2, is used comprises two header tanks 51, 52 extending in the left-right direction and separated from each other in the vertically direction, a plurality of flat heat exchange tubes 53 arranged in parallel between the two header tanks 51, 52 and separated from one another in the left-right direction, corrugated fins 54 arranged in respective air passing clearances between respective adjacent pairs of heat exchange tubes 53 and outside the heat exchange tubes 53 at the left and right ends of the evaporator and each brazed to the adjacent pair of heat exchange tubes 53 or to the end tube 53, and side plates 55 of aluminum arranged externally of and brazed to the respective fins 54 at the left and right ends. In the case of this embodiment, the upper header tank 51 will be referred to as the "first header tank," and the lower header tank 52 as the "second header tank."

The first header tank 51 comprises a header forming plate 56 made from a brazing sheet having a brazing material layer over opposite surfaces thereof, i.e., an aluminum brazing sheet according to the present embodiment, a tube

connecting plate 57 made from a brazing sheet having a brazing material layer over opposite surfaces thereof, i.e., an aluminum brazing sheet according to the present embodiment, and an intermediate plate 58 interposed between the header forming plate 56 and the tube connecting plate 57 and made from a bare metal material, i.e., a bare aluminum material, the plates 56 to 58 being arranged in superposed layers and brazed to one another.

The header forming plate 56 of the first header tank 51 has a right portion and a left portion which are provided with two outward bulging portions 59A, 59B and two outward bulging portions 59C, 59D, respectively. The two bulging portions in each of the right and left plate portions extend in the left-right direction and are spaced apart in the front-rear direction. In the present embodiment, the bulging portion 59A in the right front plate portion will be referred to as the "first outward bulging portion," the bulging portion 59B in the right rear plate portion as the "second outward bulging portion," the bulging portion 59C in the left front plate portion as the "third outward bulging portion," and the bulging portion 59D in the left rear plate portion as the "fourth outward bulging portion." The bulging portions 59A and 59D have respective openings facing down and closed with the intermediate plate 58. The bulging portions 59A to 59D are equal in bulging height, length, and width. The header forming plate 56 is made from an aluminum brazing sheet having a brazing material layer over opposite surfaces

thereof by press work.

With reference to FIG. 15, the tube connecting plate 57 is provided in each of front and rear opposite side portions thereof with a plurality of tube insertion holes 61 elongated in the front-rear direction, separated from one another in the left-right direction and extending through the thickness of the plate 57. The tube insertion holes 61 in the front right half portion are formed within the left-to-right range of the first outward bulging portion 59A of the header forming plate 56, the tube insertion holes 61 in the rear right half portion are formed within the left-to-right range of the second outward bulging portion 59B, the tube insertion holes 61 in the front left half portion are formed within the left-to-right range of the third outward bulging portion 59C, and the tube insertion holes 61 in the rear left half portion are formed within the left-to-right range of the fourth outward bulging portion 59D. The tube insertion holes 61 have a length slightly larger than the front-to-rear width of the bulging portions 59A to 59D, and have front and rear end portions projecting outward beyond the respective front and rear side edges of the corresponding bulging portions 59A to 59D. The tube connecting plate 57 is integrally provided at each of its front and rear side edges with a cover wall 62 projecting upward to the outer surface of the header forming plate 56, covering the boundary between the plate 56 and the intermediate plate 58 over the entire length thereof and brazed to the front or rear side faces of the plates 56, 58.

The projecting end of the cover wall 62 is integrally provided with engaging portions 63 separated from one another in the left-right direction, engaging with the outer surface of the plate 56 and brazed to the plate 56. The tube connecting plate 57 is made from an aluminum brazing sheet having a brazing material layer over opposite surfaces thereof by press work.

The intermediate plate 58 has communication holes 64 extending through the thickness thereof and equal in number to the number of tube insertion holes 61 in the tube connecting plate 57 for causing the holes 61 to communicate with one of the outward bulging portions 59A to 59D of the header forming plate 56 therethrough in corresponding relation. The communication holes 64 are substantially larger than the insertion holes 61 (see FIG. 17). The communication holes 64 are positioned in corresponding relation with the respective tube insertion holes 61 of the tube connecting plate 57. The tube insertion holes 61 in the front right half portion of the tube connecting plate 57 are held in communication with the interior of the first outward bulging portion 59A through the communication holes 64 in the front right half portion of the intermediate plate 58. The tube insertion holes 61 in the rear right half portion of the plate 57 are held in communication with the interior of the second outward bulging portion 59B through the communication holes 64 in the rear right half portion of the intermediate plate 58. The tube insertion holes 61 in the front left half

portion of the plate 57 are held in communication with the interior of the third outward bulging portion 59C through the communication holes 64 in the front left half portion of the intermediate plate 58. The tube insertion holes 61 in the rear left half portion of the plate 57 are held in communication with the interior of the fourth outward bulging portion 59D through the communication holes 64 in the rear left half portion of the intermediate plate 58. All the communication holes 64 communicating with the interior of the first bulging portion 59A, as well as all the communication holes 64 communicating with the interior of the second bulging portion 59B, are held in communication through first communication portions 66 formed by removing the portions between respective left-to-right adjacent pairs of communication holes 64 in the intermediate plate 58. The communication holes 64 in communication with the third bulging portion 59C communicate with the respective communication holes 64 communicating with the fourth bulging portion 59D via second communication portions 65 formed by cutting away the portions between respective front-to-rear adjacent pairs of communication holes 64 in the intermediate plate 58, whereby the interior of the third bulging portion 59C and the interior of the fourth bulging portion 59D communicate with each other. The intermediate plate 58 is made from a bare aluminum material by press work.

Each of the three plates 56, 57, 58 is provided at the right end thereof with two rightward projections 56a, 57a,

58a spaced apart in the front-rear direction. The intermediate plate 58 has a cutout 67 extending from the outer end of each of the two outward projections 58a to the communication hole 64 at the right end. These cutouts 67 provide in the first header tank 51 a refrigerant inlet 68 communicating with the interior of the first outward bulging portion 59A and a refrigerant outlet 69 communicating with the interior of the second outward bulging portion 59B (see FIG. 17).

The second header tank 52 has nearly the same construction as the first header tank 51, and like parts will be designated by like reference numerals (see FIG. 16). The header forming tanks 51, 52 are arranged with their tube connecting plates 57 facing toward each other. The second header tank 52 differs from the first header tank 51 in that the header forming plate 56 has two outward bulging portions 71A, 71B extending from a right end portion thereof to a left end portion thereof and spaced apart in the front-rear direction so as to be opposed to both the first and third bulging portions 59A, 59C and both the second and fourth bulging portions 59B, 59D, respectively, that all the communication holes 64 communicating with each of the bulging portions 71A, 71B are held in communication through communication portions 72 formed by removing the portions between respective left-to-right adjacent pairs of communication holes 64 in the intermediate plate 58, that the two bulging portions 71A, 71B are not in communication and

that the right ends of the three plates 56, 57, 58 are provided with no rightward projections. The bulging portions 71A, 71B are equal to the bulging portions 59A to 59D of the first header tank 51 with respect to the bulging height and width.

The header tanks 51, 52 are made in the following manner. First are formed header forming plates 56 having outward bulging portions 59A to 59D or outward bulging portions 71A, 71B, tube connecting plates 57 having tube insertion holes 61, cover walls 62, and engaging portion forming lugs 63A (represented by solid lines in FIGS. 15 and 16) extending straight from each of the cover walls 62, and intermediate plates 58 having communication holes 64 and communication portions 65, 66 or 72. Subsequently, the three plates 56, 57, 58 for each of the header tanks 51, 52 are fitted together in superposed layers, and then the lugs 63A are bent to form engaging portions 63. Utilizing the brazing material layers of the plates 56, 57, the three plates 56, 57, 58 of each assembly are then brazed to one another, the cover walls 62 are brazed to the front and rear side faces of the intermediate plate 58 and header forming plate 56, and the engaging portions 63 are brazed to the plate 56.

Each of the heat exchange tubes 53 is made from a metal extrudate, i.e., an aluminum extrudate in the present embodiment, is in the form of a flat tube having an increased width in the front-rear direction and has inside thereof a plurality of refrigerant channels 53a extending

longitudinally thereof and arranged in parallel. The heat exchange tubes 53 are brazed to the tube connecting plates 57 of the two header tanks 51, 52 using the brazing material layers of the plates 57, with their opposite ends placed into the respective tube insertion holes 61 of the tanks 51, 52. Each end of the tube 53 is placed into the communication hole 64 of the intermediate plate 58 to an intermediate portion of the thickness thereof (see FIG. 13). Between the two header tanks 51, 52, a plurality of tube groups 73, each comprising a plurality of heat exchange tubes 53 arranged in parallel and separated from one another in the left-right direction, are arranged in rows, i.e., in two rows separated from each other in the front-rear direction. The heat exchange tubes 53 positioned in the right half of the front tube group 73 have upper and lower ends which are joined to the respective header tanks 51, 52 so as to communicate with the interior of the first bulging portion 59A and the interior of the front bulging portion 71A. The heat exchange tubes 53 positioned in the left half of the front tube group 73 have upper and lower ends which are joined to the respective header tanks 51, 52 so as to communicate with the interior of the third bulging portion 59C and the interior of the front bulging portion 71A. The heat exchange tubes 53 positioned in the right half of the rear tube group 73 have upper and lower ends which are joined to the respective header tanks 51, 52 so as to communicate with the interior of the second bulging portion 59B and the interior of the rear bulging portion 71B.

The heat exchange tubes 53 positioned in the left half of the rear tube group 73 have upper and lower ends which are joined to the respective header tanks 51, 52 so as to communicate with the interior of the fourth bulging portion 59D and the interior of the rear bulging portion 71B.

Each of the corrugated fins 54 is made in a wavy form from an aluminum brazing sheet having a brazing material layer over opposite surfaces thereof. Connecting portions interconnecting crest portions and trough portions of the fin are provided with a plurality of louvers arranged in parallel in the front-rear direction. The corrugated fin 54 is used in common for the front and rear tube groups 73 and has a front-to-rear width which is approximately equal to the distance from the front edge of heat exchange tube 53 of the front tube group 73 to the rear edge of the corresponding heat exchange tube 53 of the rear tube group 73. Instead of using one corrugated fin 54 for the front and rear tube groups 73 in common, a corrugated fin may be provided between each adjacent pair of heat exchange tubes 53 in each of the tube groups 73.

In the evaporator 50 described above, a right front portion of the first header tank 51 including the first outward bulging portion 59A serves as a refrigerant inlet header 74 serving as a refrigerant flow section, and a right rear portion of the first header tank 51 including the second outward bulging portion 59B serves as a refrigerant outlet header 70 serving as a refrigerant flow section. All the

heat exchange tubes 53, the left portion of the first header tank 51, and the second header tank 52 form a refrigerant circulation path establishing communication between the refrigerant inlet header 74 and the refrigerant outlet header 70.

An inflow pipe 75 of piping and an outflow pipe 75 of piping are connected to the refrigerant inlet header 74 and the refrigerant outlet header 70, respectively, by means of a refrigerant flow section connection structure 76.

With reference to FIGS. 17 to 20, the refrigerant flow section connection structure 76 comprises a channel member 77 joined to the refrigerant inlet header 74 and the refrigerant outlet header 70 while being fitted to the two rightward projections 56a, 57a, 58a of the three plates 56, 57, 58 of the first header tank, the inflow and outflow pipes 75 of piping, a fixing member 78 adapted to fix the pipes 75 of piping to the channel member 77, and a tightening means for joining the channel member 77 and the fixing member 78 together.

The channel member 77 is made from metal, i.e., a bare aluminum material in the present embodiment, assumes the form of a block having a horizontally elongated rectangular shape as viewed from the right side, and has an inflow refrigerant channel 80 whose one end opening communicates with the interior of the refrigerant inlet header 74 via the refrigerant inlet 68 and whose other end opens at the right side face thereof, and an outflow refrigerant channel 81

whose one end opening communicates with the interior of the refrigerant outlet header 70 via the refrigerant outlet 69 and whose other end opens at the right side face thereof. The refrigerant channels 80, 81 have respective insertion portions 80a, 81a formed at respective right end portions and having an inner cylindrical surface. Two projecting portions 82 are integrally formed on the right side face of the channel member 77 at corresponding front-rear opposite end portions thereof, projects rightward, and extends along corresponding opposite end surfaces of the fixing member 78. Each of the projecting portions 82 has a groove 83 formed on its front-rear inner surface and extending in the vertically direction. Each of the grooves 83 opens at the upper and lower surfaces of the corresponding projecting portion 82. A side wall partially constituting each of the grooves 83 and located on a side toward the projecting end of the projecting portion 82 serves as an engaging portion 84 that engages with a projection 88 of the fixing member 78 to be described later. The channel member 77 is brazed to the first header tank 51 by use of a brazing sheet having a brazing material layer over opposite surfaces thereof, i.e., an aluminum brazing sheet 85 in the present embodiment.

Each of the pipes 75 of piping has an annular bead 75a (annular projection) formed thereon in the vicinity of a distal end thereof along the entire circumference thereof. An O-ring 86 is fitted to the outer surface of a portion of each of the pipes 75 of piping located distally of the

annular bead 75a.

The fixing member 78 is made from metal, i.e., a bare aluminum material in the present embodiment, and assumes the form of a block having a horizontally elongated circular shape as viewed from the right side. Two cutouts 87 are formed at front-rear opposite end portions of the fixing member 78 in such a manner as to open downward (at lower side face), and adapted to be fitted to portions of the corresponding pipes 75 of piping located rightward (located on the longitudinally inner side) of the respective annular beads 75a. Two recesses 78a into which the corresponding annular beads 75a of the pipes 75 of piping are fitted are formed on the right side face of the fixing member 78 around the corresponding left end openings of the cutouts 87. The projections 88 are integrally formed on the corresponding front-rear opposite end surfaces of the fixing member 78, project frontward and rearward, respectively, and are adapted to be fitted into the corresponding grooves 83 of the two projecting portions 82 of the channel member 77. The projecting height of the projections 88 is equal to the depth of the grooves 83, and the left-right length of the projections 88 is equal to the left-right width of the grooves 83. The respective front and rear surfaces of the two projections 88 assume the forms of frontward and rearward projecting arcs, respectively, as viewed from the right side.

The tightening means comprises a single threaded hole 90 formed in the channel member 77 and extending leftward

from a front-rear central portion of the right side face of the channel member 77, and a bolt 92 to be inserted from the right side through a bolt insertion hole 91 formed in a front-rear central portion of the fixing member 78 and extending therethrough in the left-right direction, and to be screwed into the threaded hole 90 of the channel member 77.

The inflow and outflow pipes 75 of piping are connected to the refrigerant inlet header 74 and the refrigerant outlet header 70, respectively, in the following manner.

First, portions of the inflow and outflow pipes 75 of piping located distally of the respective annular beads 75a into the corresponding insertion portions 80a, 81a of the inflow and outflow refrigerant channels 80, 81 of the channel member 77. Next, the fixing member 78 is moved downward from the upper side so as to fit the two projections 88 into the corresponding grooves 83 of the two projecting portions 82 of the channel member 77, to fit portions of the inflow and outflow pipes 75 of piping located rightward of the respective annular beads 75a into the corresponding cutouts 87, and to align the bolt insertion hole 91 and the threaded hole 90 with each other. At this time, the annular beads 75a of the two pipes 75 of piping are fitted into the corresponding recesses 78a of the fixing member 78. Then, the bolt 92 is inserted from the right side through the bolt insertion hole 91 of the fixing member 78 and screwed into the threaded hole 90 of the channel member 77. Thus, the inflow and outflow pipes 75 of piping are connected to the

refrigerant inlet and outlet headers 74, 70, respectively.

The evaporator 50 provides a supercritical refrigeration cycle along with a compressor, a gas cooler, an expansion valve serving as a pressure reducing device, an accumulator serving as a gas-liquid separator, and an intermediate heat exchanger for effecting heat exchange between a refrigerant flowing out of the gas cooler and a refrigerant flowing out of the evaporator and passing through the gas-liquid separator, and the refrigeration cycle is installed in vehicles, for example, in motor vehicles, as a vehicle air conditioner.

With the evaporator 50 described above, CO_2 passing through a pressure reducing device and undergoing pressure reduction therein flows through the inflow pipe 75 of piping and the inflow refrigerant channel 80 of the channel member 77, then flows through the refrigerant inlet 68 into the interior of the refrigerant inlet header 74, and thereafter dividedly flows into the refrigerant channels 53a of all the heat exchange tubes 53 in communication with the interior of the first bulging portion 59A. The CO_2 in the channels 53a flows down the channels 53a and enters the front outward bulging portion 71A of the second header tank 52. The CO_2 in the portion 71A flows leftward through this portion 71A, the communication holes 64, and the communication portions 72, then dividedly flows into the channels 53a of all the heat exchange tubes 53 in communication with the interior of the third outward bulging portion 59C, changes its course, flows

upward through the channels 53a and enters the third outward bulging portion 59C of the first header tank 51. The CO_2 in the bulging portion 59C flows through the second communication portions 65 of the intermediate plate 58 of the first header tank 51 into the fourth outward bulging portion 59D, dividedly flows into the channels 53a of all the heat exchange tubes 53 communicating with the fourth bulging portion 59D, changes its course, flows down the channels 53a, and enters the rear outward bulging portion 71B of the second header tank 52. The CO_2 in the bulging portion 71B then flows rightward through this portion 71B, the communication holes 64, and the communication portions 72, dividedly flows into the channels 53a of all the heat exchange tubes 53 communicating with the second outward bulging portion 59B, changes its course, flows up the channels 53a, and enters the refrigerant outlet header 70 of the first header tank 51. The CO_2 thereafter flows out of the evaporator 50 from the outflow pipe 75 of piping via the refrigerant outlet 69 and the outflow refrigerant channel 81 of the channel member 77. While flowing through the refrigerant channels 53a of the heat exchange tubes 53, the CO_2 is subjected to heat exchange with the air flowing through the air passing clearances in the direction of arrow X shown in FIG. 12 and flows out from the evaporator in a vapor phase.

In Embodiment 3, the channel member 77 has the engaging portions 84, whereas the fixing member 78 has the projections 88 which engage with the corresponding engaging portions 84.

This may be reversed such that the channel member 77 has the projections 88, whereas the fixing member 78 has the engaging portions 84 which engage with the corresponding projections 88.

Although CO_2 is used as the supercritical refrigerant of the supercritical refrigeration cycle according to the foregoing Embodiments 1 to 3, the refrigerant is not limitative, but ethylene, ethane, nitrogen oxide, or the like is alternatively used.

Embodiment 4

This embodiment is shown in FIG. 21 and is implemented by applying the present invention to connection between pipes of piping as refrigerant flow sections in a supercritical refrigeration cycle. In the description of Embodiment 4, the upper, lower, left-hand, and right-hand sides of FIG. 21 will be referred to as "upper," "lower," "left," and "right," respectively.

The refrigerant flow section connection structure 100 comprises a first channel member 102 fixedly attached to a distal end portion of a first pipe 101 of piping, a second channel member 104 fixedly attached to a distal end portion of a second pipe 103 of piping, and a tightening means for joining the channel members 102 and 104 together.

The first channel member 102 is made from metal, i.e., a bare aluminum material in the present embodiment, and assumes the form of a block. The first channel member 102 has a refrigerant channel 105 formed in an upper end portion

thereof and extending therethrough in the left-right direction. The refrigerant channel 105 has a large-diameter portion 105a formed at a left end portion thereof. A distal end portion of the first pipe 101 of piping is inserted into the large-diameter portion 105a of the refrigerant channel 105 and joined to the first channel member 102 by welding or brazing. A male pipe portion 102a projecting rightward and having an outer cylindrical surface is integrally formed on the right side face of the first channel member 102 around the right end opening of the refrigerant channel 105. An O-ring 106 is fitted to the outer surface of the male pipe portion 102a. The first channel member 102 has a projecting portion 107 integrally formed on an upper end portion thereof, projecting rightward, and extending along the upper end surface of the second channel member 104, as well as a groove 108 formed on the lower surface of the projecting portion 107 and extending in the front-rear direction. The front and rear ends of the groove 108 open at the front and rear side faces, respectively, of the projecting portion 107. A side wall partially constituting the groove 108 and located on a side toward the projecting end of the projecting portion 107 serves as an engaging portion 109 that engages with a projection 112 of the second channel member 104 to be described later.

The second channel member 104 is made from metal, i.e., a bare aluminum material in the present embodiment, and assumes the form of a block having a vertically elongated

rectangular shape as viewed from the rear side. The second channel member 104 has a refrigerant channel 111 formed in an upper end portion thereof, extending therethrough in the left-right direction, and adapted to communicate with the refrigerant channel 105 of the first channel member 102. An insertion portion 111a which has an inner cylindrical surface and into which the male pipe portion 102a of the first channel member 102 is formed at a left end portion of the refrigerant channel 111. A large-diameter portion 111b is formed at a right end portion of the refrigerant channel 111. A distal end portion of the second pipe 103 of piping is inserted into the large-diameter portion 111b and joined to the second channel member 104 by welding or brazing. A projection 112 is integrally formed on the upper end surface of the second channel member 104, projects upward, and is adapted to be fitted into the groove 108 of the first channel member 102. The projecting height of the projection 112 is equal to the depth of the groove 108, and the left-right length of the projection 112 is equal to the left-right width of the groove 108. Although unillustrated, the upper surface of the projection 112 assumes the form of an upward projecting arc as viewed from the left side. The distance between the centerline of the insertion portion 111a of the refrigerant channel 111 and the upper end of the projection 112 is equal to the distance between the centerline of the outer surface of the male pipe portion 102a and the bottom surface of the groove 108.

The tightening means comprises a threaded hole 113 formed in a lower end portion of the second channel member 104 and extending therethrough in the left-right direction, and a bolt 115 to be inserted from the left side through a bolt insertion hole 114 formed in a lower end portion of the first channel member 102 and extending therethrough in the left-right direction, and to be screwed into the threaded hole 113 of the second channel member 104.

The first pipe 101 of piping and the second pipe 103 of piping are connected in the following manner.

First, the male pipe portion 102a of the first channel member 102 is inserted into the insertion portion 111a of the refrigerant channel 111 of the second channel member 104. At this time, the bolt insertion hole 114 of the first channel member 102 is offset from the threaded hole 113 of the second channel member 104, i.e., offset toward the near side of the paper on which FIG. 21 appears, in the present embodiment. Then, the first channel member 102 is rotated about the centerline of the outer surface of the male pipe portion 102a, thereby fitting the projection 112 of the second channel member 102 into the groove 108 of the first channel member 102 and aligning the bolt insertion hole 114 and the threaded hole 113 with each other. The bolt 115 is inserted from the left side through the bolt insertion hole 114 of the first channel member 102 and screwed into the threaded hole 113 of the second channel member 104. Thus, the pipes 101 and 103 of piping are connected together.

In Embodiment 4, the first channel member 102 has the engaging portion 109, whereas the second channel member 104 has the projection 112 which engages with the engaging portion 109. This may be reversed such that the first channel member 102 has the projection 112, whereas the second channel member 104 has the engaging portion 109 which engages with the projection 112.

As in the case of Embodiment 4, the connection structures of Embodiments 1 to 3 can be applied to connection between pipes of piping for use in a refrigeration cycle. In this case, an end portion of one pipe of piping is inserted into an end portion of the channel member 26 (77) in which the insertion portion 28a (80a, 81a) of the refrigerant channel 28 (80, 81) is formed, and joined to the channel member 26 (77). The other pipe of piping is fixed by means of the fixing member 27 (78).

INDUSTRIAL APPLICABILITY

The refrigerant flow section connection structure for use in a refrigeration cycle according to the present invention is preferably used for connecting pipes of piping, connecting refrigerant flow sections, or connecting a pipe of piping and a refrigerant flow section in a supercritical refrigeration cycle that uses a supercritical refrigerant, such as CO_2 (carbon dioxide).